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Building Models from Breeding Bird Surveys

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Where can we expect to find species of high conservation concern?

- Motivation:
  - Focus scarce conservation resources
  - Provide regional context to local conservation action
  - Lay the groundwork for estimating regional population size

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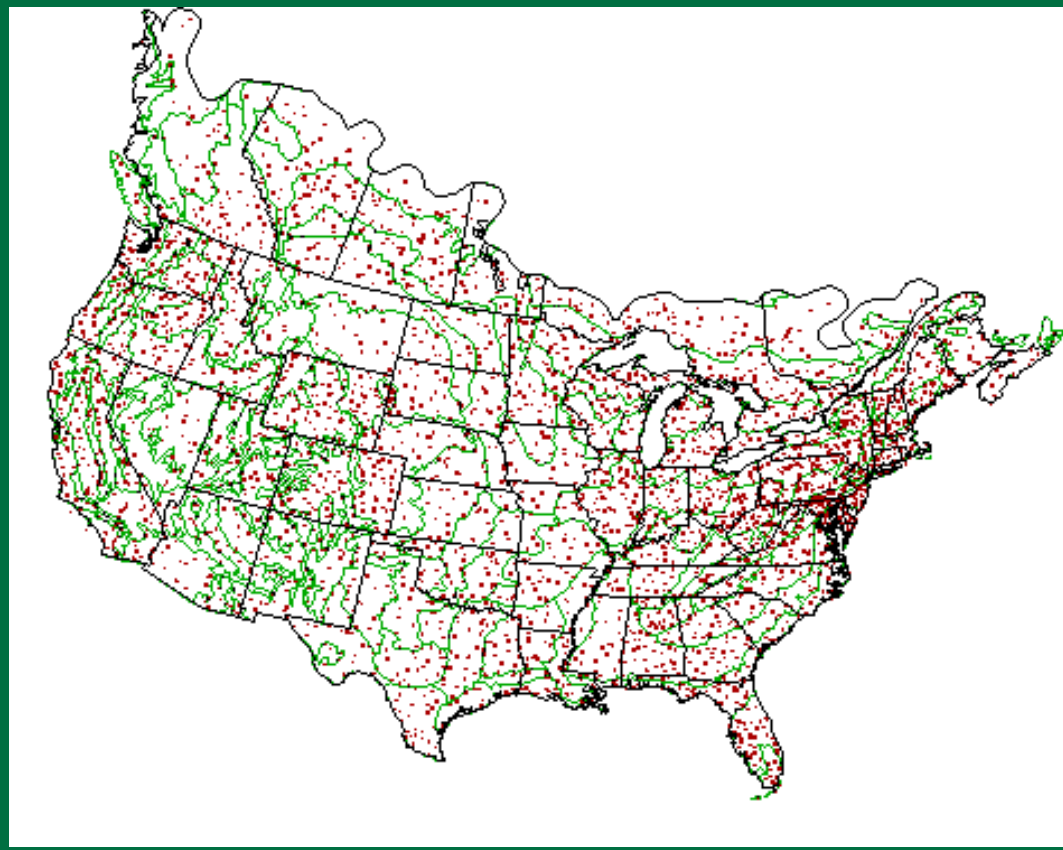
What is the Breeding Bird Survey?

- 1966 inception
- 50 stops on 2ndary road, 0.5 mile apart
- All birds seen or heard w/in 3 min
- 3700 active routes
- 2900 annually run
- Spatially hetero-geneous



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Important Issues to Address When Modeling Bird-habitat Associations

- Count-based
- Road-side
- Annual, spring
- Volunteer
- Potentially spatially correlated
- Areally dimensionless
- Species detectability
- Index to abundance (relative abundance)

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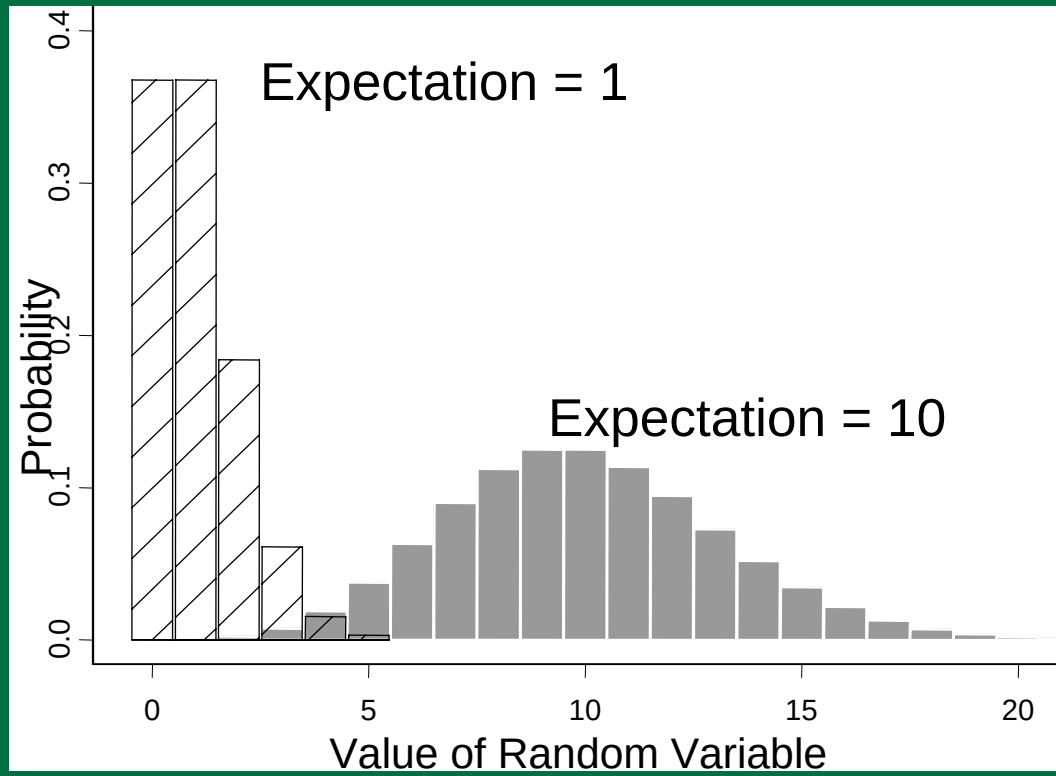
Count-based

- Use of linear regression for count-based outcomes results
  - inefficient,
  - inconsistent, and
  - biased estimates
- Particularly problematic when counts are low



CERW < **0.1** (90% zeroes)
HESP < **0.1** (95%)
GWWA = **0.4**
GRSP = **0.8**
SEWR = **2.8**
BOBO = **9.7** (15%)

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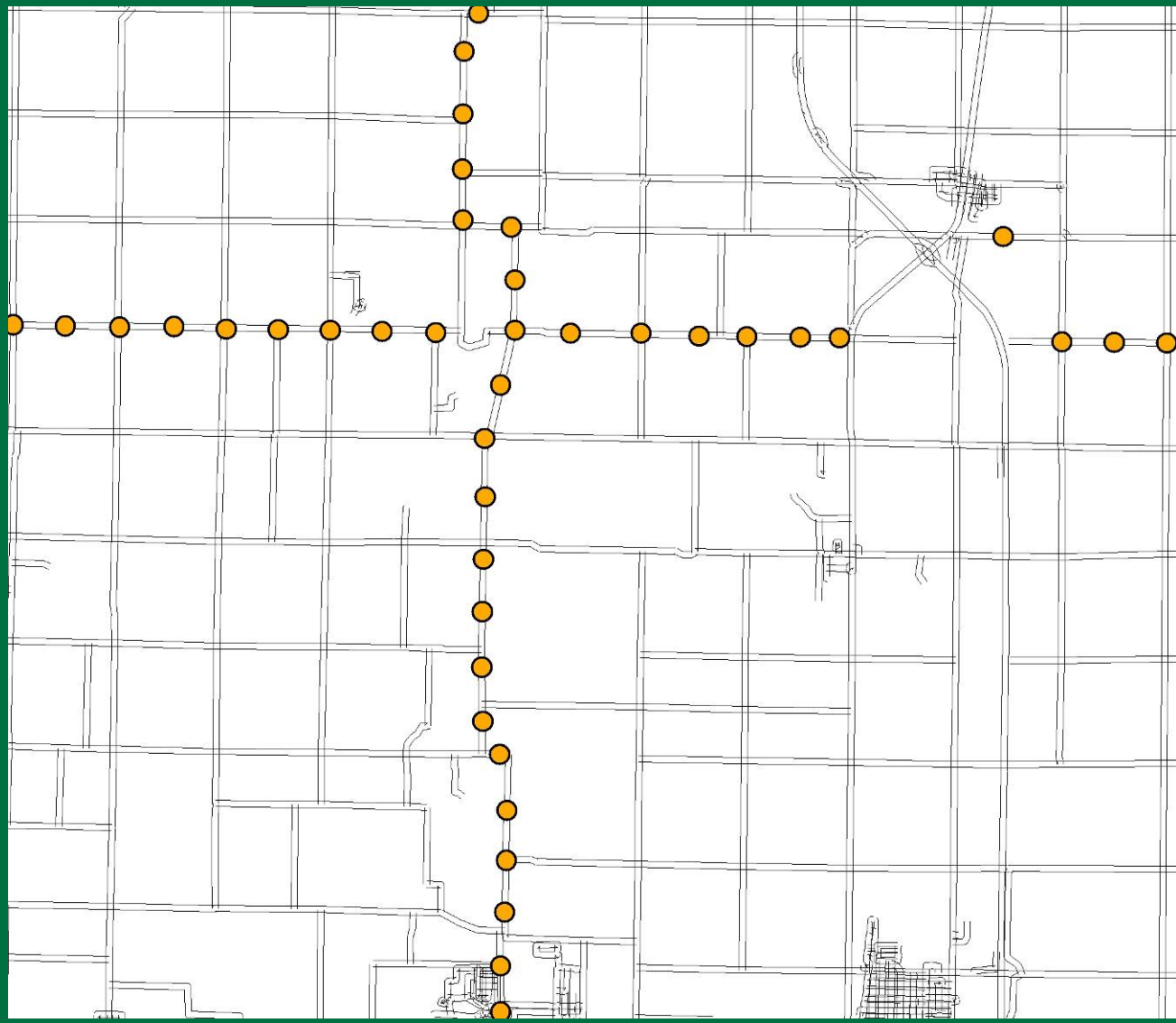
Road-side survey

- Biggest criticism of the BBS
- How much does this bias the counts?



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Annual spring survey

- Each route comprised of 50 stops, each 3 minutes long
- Completed only one time in spring
- Total route time surveyed: 150 minutes

- Is a 3 min (stop) or 150 min (route) survey sufficient?
- Is it better to include multiple years to reduce noise in the expectation?

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BBS surveys (primarily) breeding males

- Non-floaters and females are less frequently counted

- Is it enough to simply double the observed counts to obtain an estimate of the female population?
- What about the non-territorial birds?

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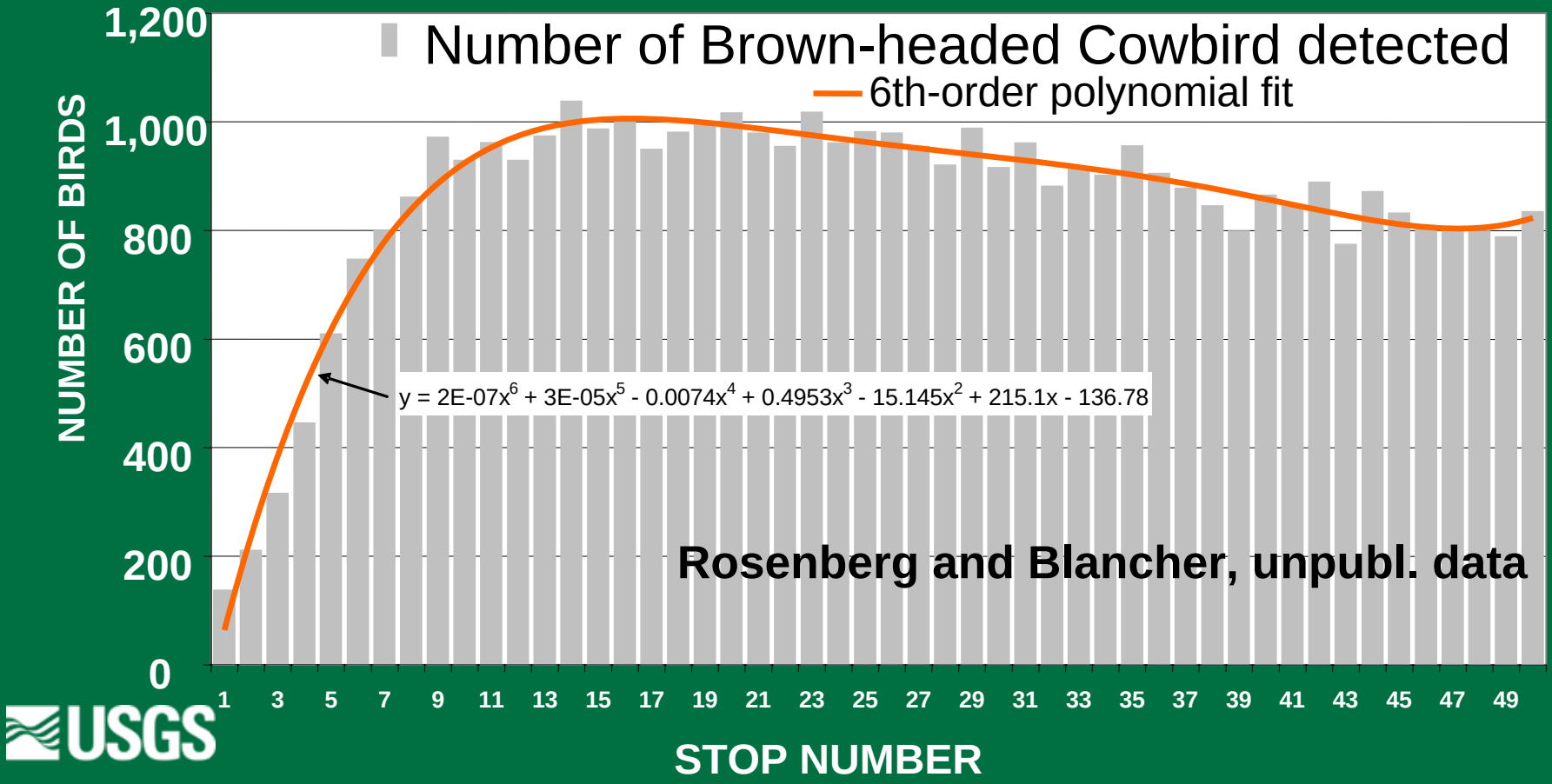
Time of day and season

- **Calling propensity varies over the course of the day and season**



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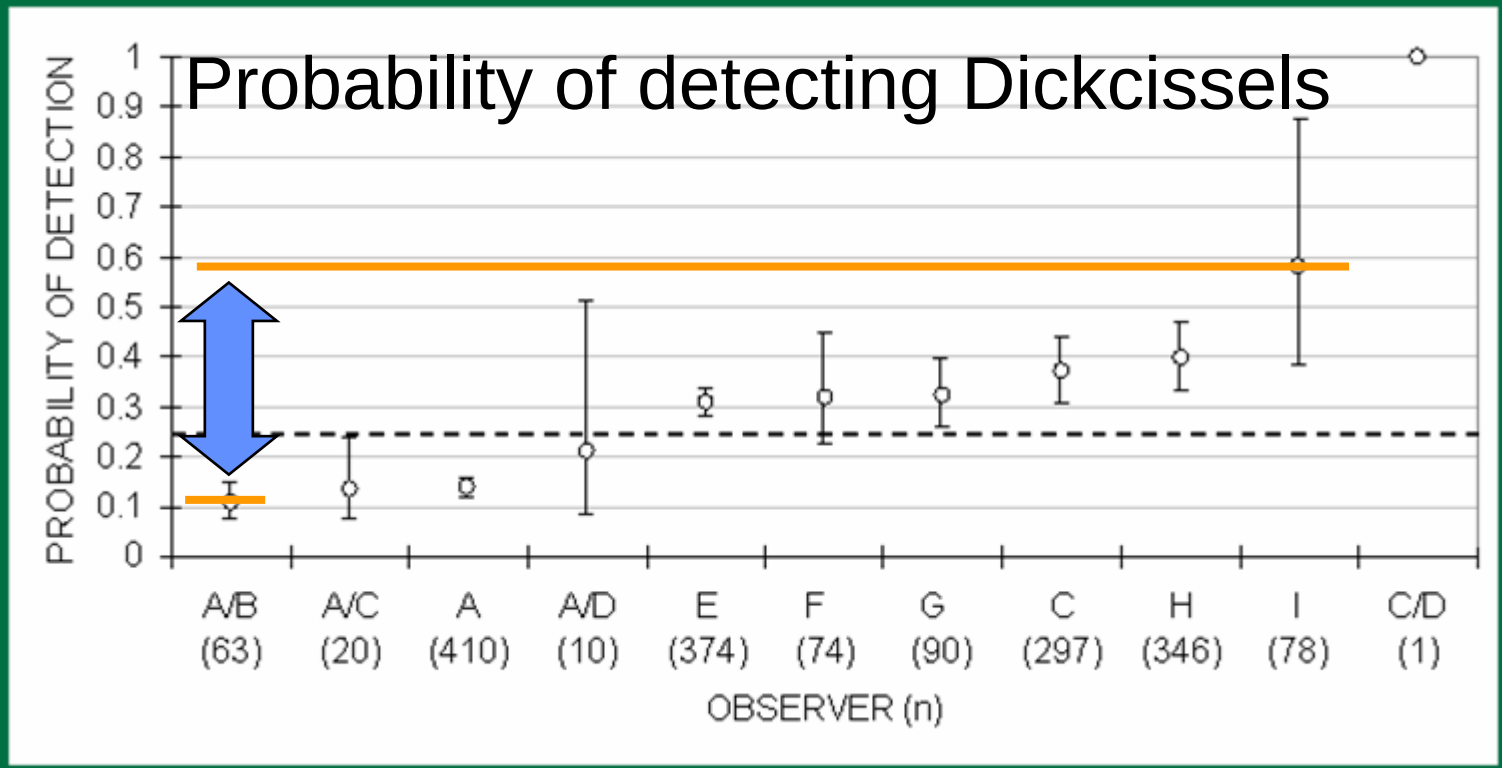
Volunteers with varying levels of ability

- **Observers differ in how they see and hear birds**
- **Novice observers often overwhelmed**

6x difference between best and worst



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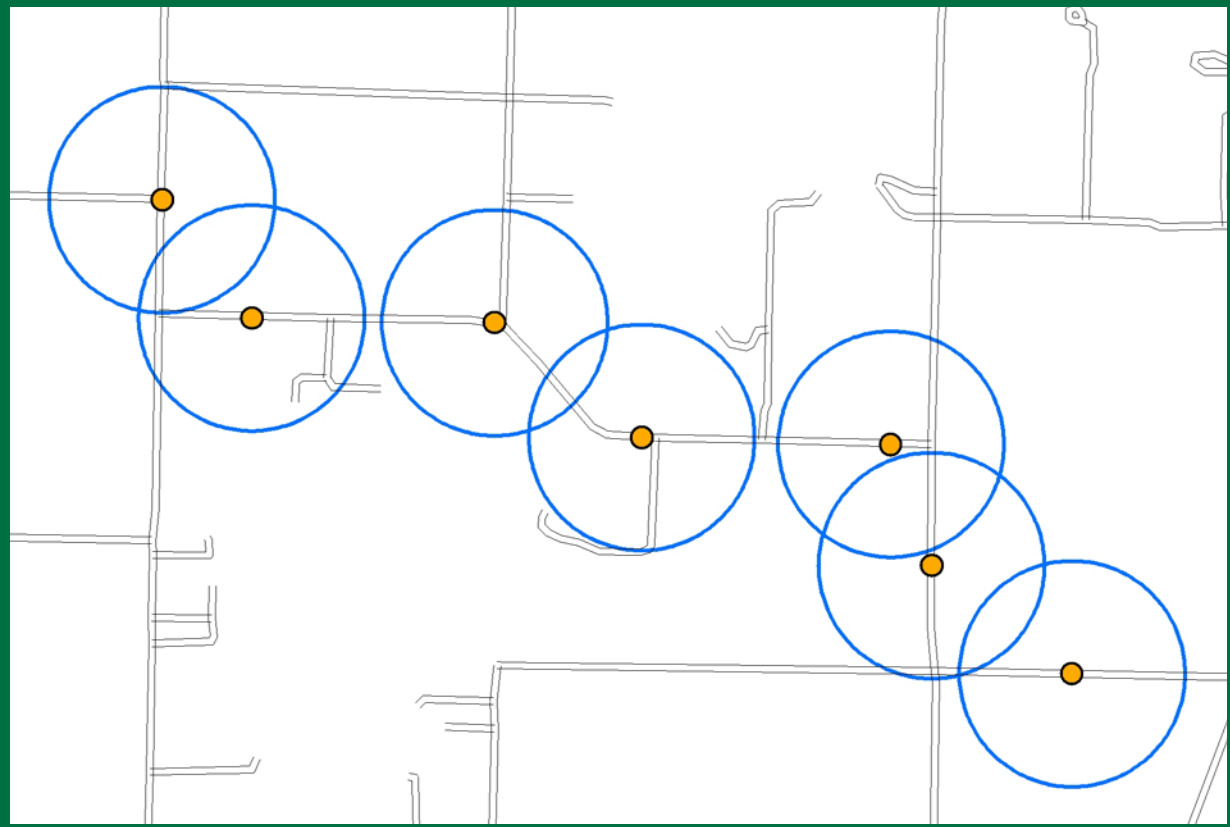
Spatial correlation: nuisance or insight?

- Bias parameter estimates
- Improperly narrow confidence intervals



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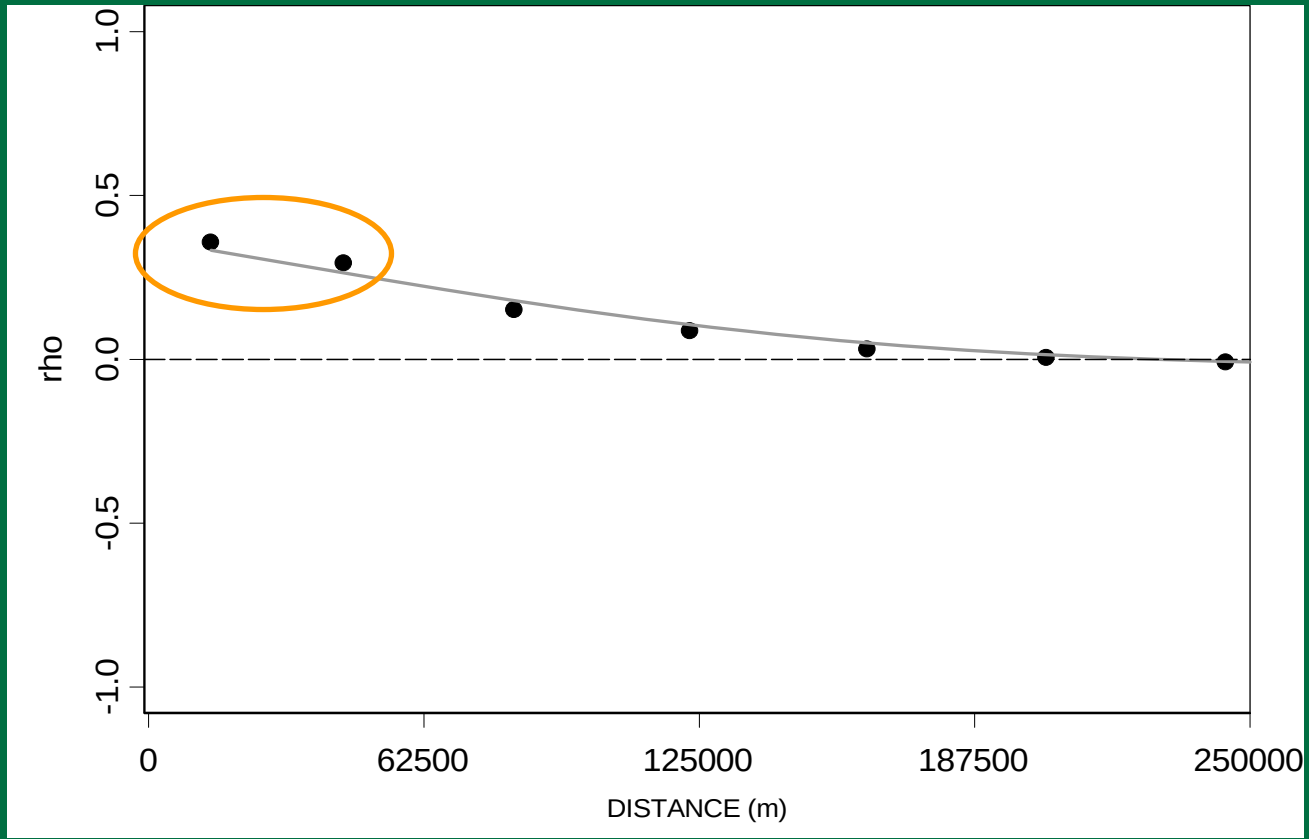
Spatial Correlation

- Correlogram of Cerulean Warbler abundance in the Appalachians

- Rho > 0.25 at distances < 50 km



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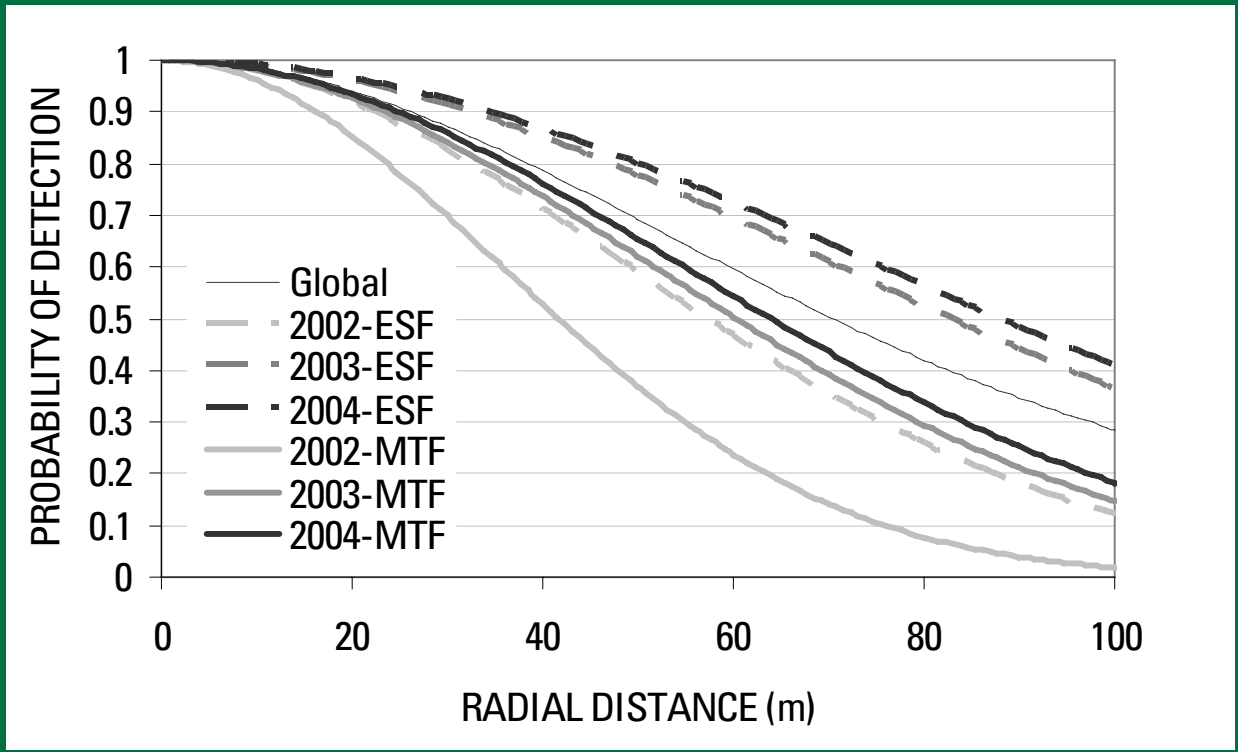
Species Detectability

- Detectability varies as a fcn of species, observer, year, and landcover
- ~50% of known territory individuals were detected by auditory means (Earnst and Heltzel 2005)

Probability of detecting Yellow-billed Cuckoos



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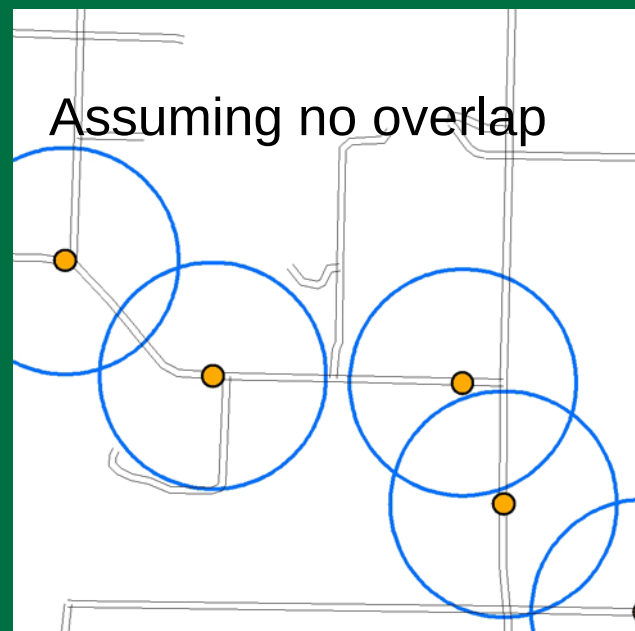
Areally dimensionless

- Is a 400 m listening radius reasonable for all birds?
  - No. Amer. Landbird Cons. Plan assigned various listening radii
  - Are 80 m, 125 m, 200 m, 400 m, 800 m reasonable?

80 m radius ≈ 2.0 ha	⇨	100 ha
125 m ≈ 5 ha	⇨	250 ha
200 m ≈ 13 ha	⇨	630 ha
400 m ≈ 50 ha	⇨	2,500 ha
800 m ≈ 201 ha	⇨	10,000 ha

2 orders of magnitude



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Areally dimensionless

- Positionally uncertain because most stops are not geo-located and routes are not always updated when changes occur

- Uncertainty as to where surveys are taken and how much area to attribute to them
- Density = Count of Species / Area of Habitat

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Index to abundance (relative abundance)

- If these various factors are not accommodated, resulting counts from BBS are only indices of abundance rather than estimates of population size

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Building Models of Rare Bird Abundance in the Prairie Hardwood Transition with Breeding Bird Survey Data

Modeling BBS Counts ~ f(Environmental Variables)

- Counts derived between 1981 and 2001
- Environmental Variables were only those which could be remotely sensed or regionally mapped
- Spatially correlated counts, Poisson distribution of counts, observer and year effects

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Spatial Poisson Count Model

$$Z(s_i) = \mu(s_i) + \Sigma c_{ik}[Z(s_k) - \mu(s_k)] + \omega(s_i) + \gamma(s_i) + \varepsilon(s_i)$$

- μ **Environmental effects**
- ω **Observer effects**: ***Individual effect, with novice observer counts deleted***
- γ **Year effects**: ***to accommodate observed annual variation and decline in abundance***
- **Spatial CAR (Conditional AutoRegression)**: ***correlation***
- ε **Extra-poisson variation**: ***zero-inflation***

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Hierarchical Modeling

- Correlation may occur because of design, over time, and/or across space
- Hierarchical: clustering of β for observer, year, and route effects because of group-level correlation
- Bayesian: Data and prior specification used to identify a posterior distribution for parameter estimates (β)
  - Standardized Likelihood x Data = Posterior Probability
  - Combine prior belief with the likelihood of the data to obtain posterior inferences

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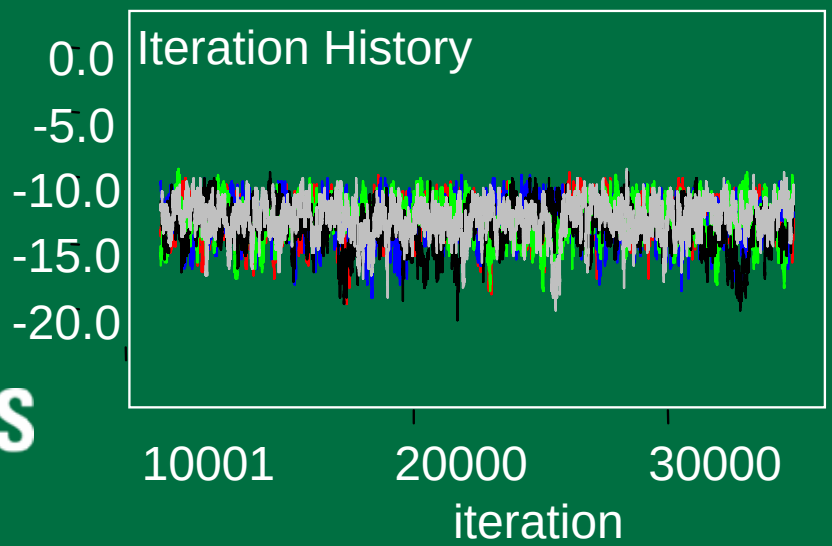
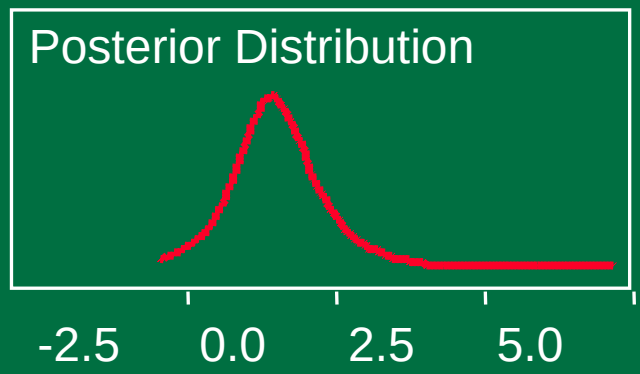
Markov chain Monte Carlo

- There is NO frequentist approach that would accomodate 1) Poisson nature of BBS, 2) nuisance effects due to correlated observer and year effects, AND 3) potential spatial correlation
- Model fitting in WinBUGS





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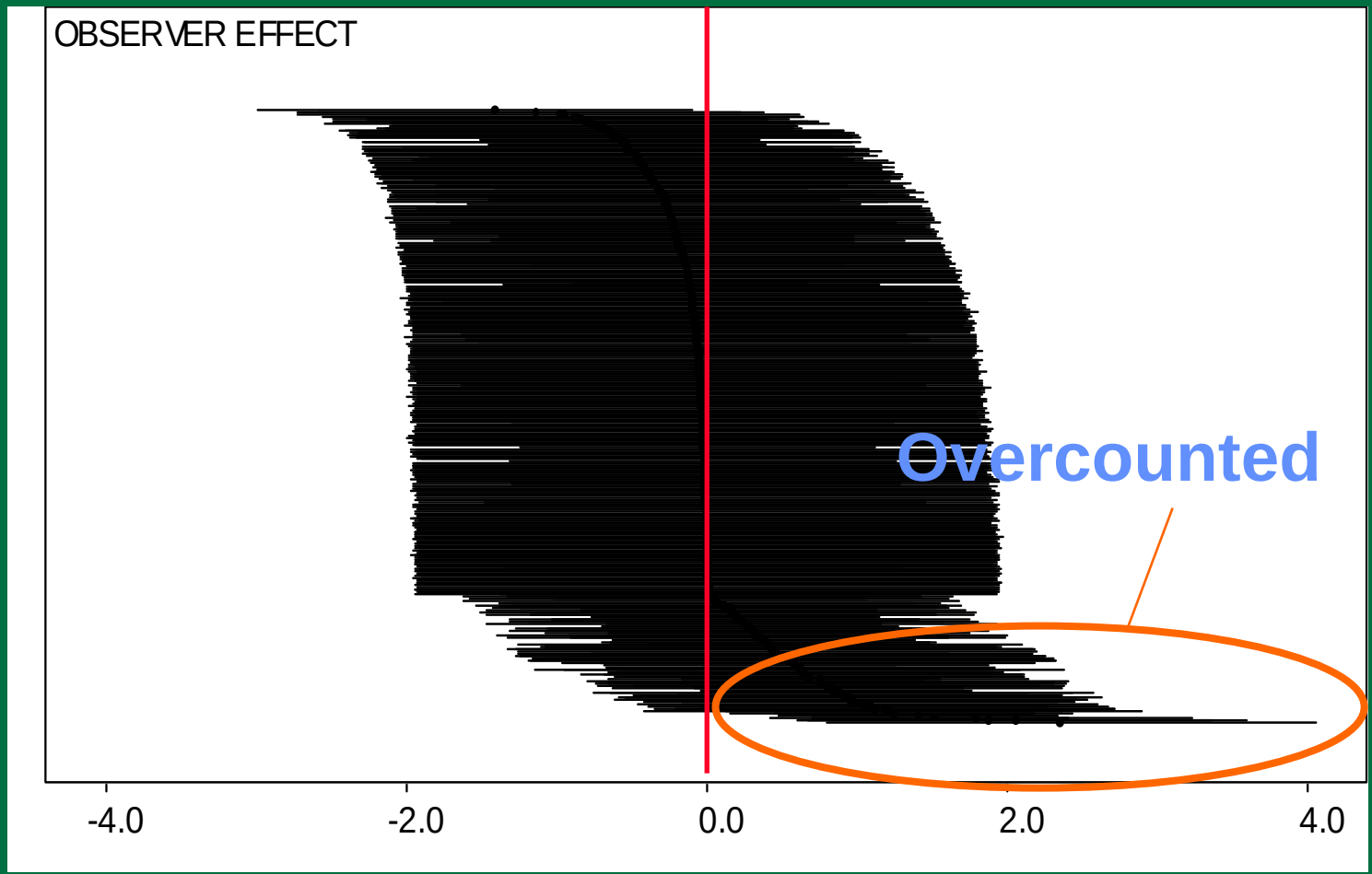
Observer Effect (rank ordered)

- CERW counts in the Appalachians; 486 observers



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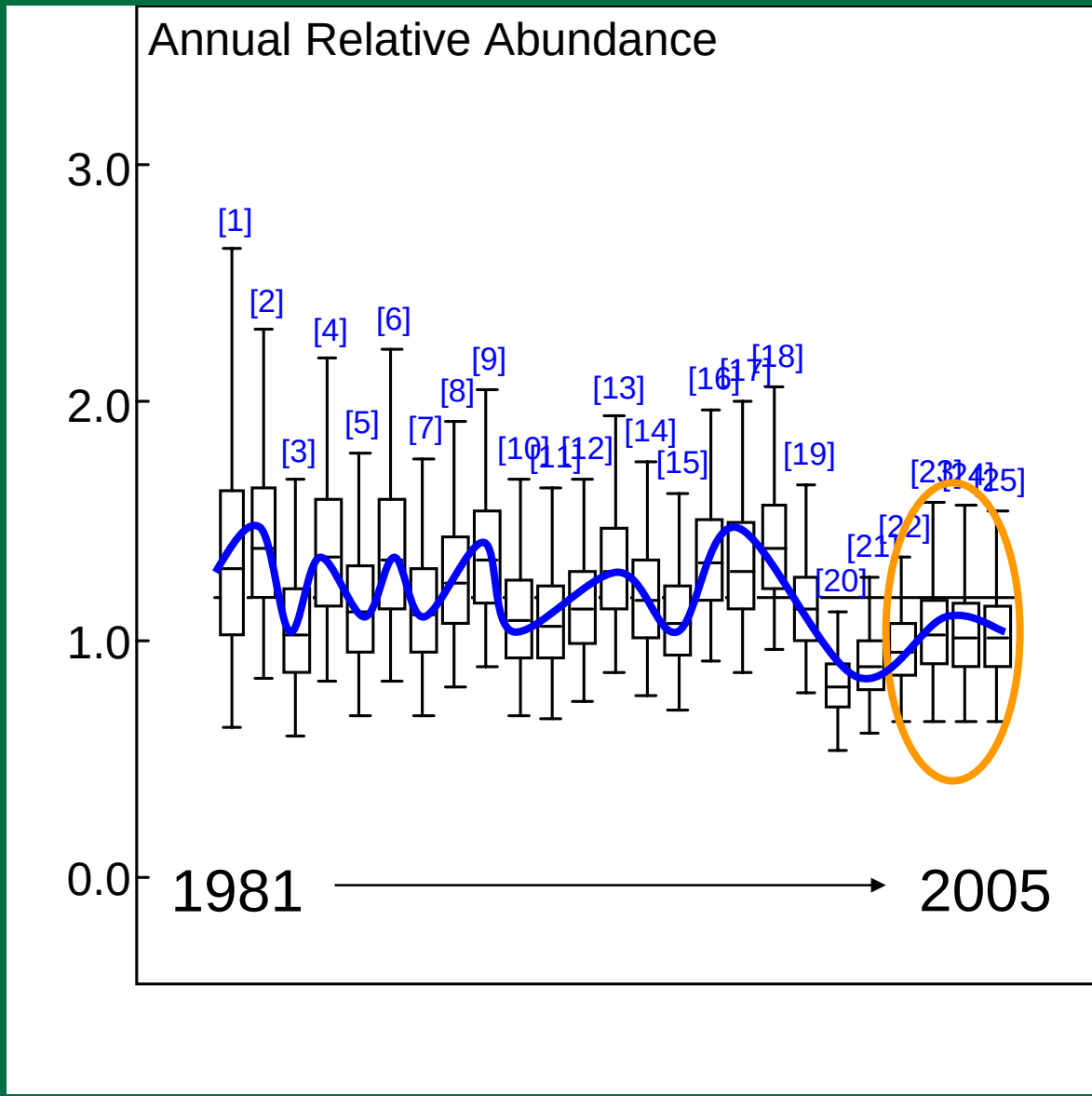
Year Effect

- CERW counts in the Appalachians
- Annual variation AND trend used to adjust counts
- Bayesian approach allows imputation to future years



Route Effect (rank ordered)

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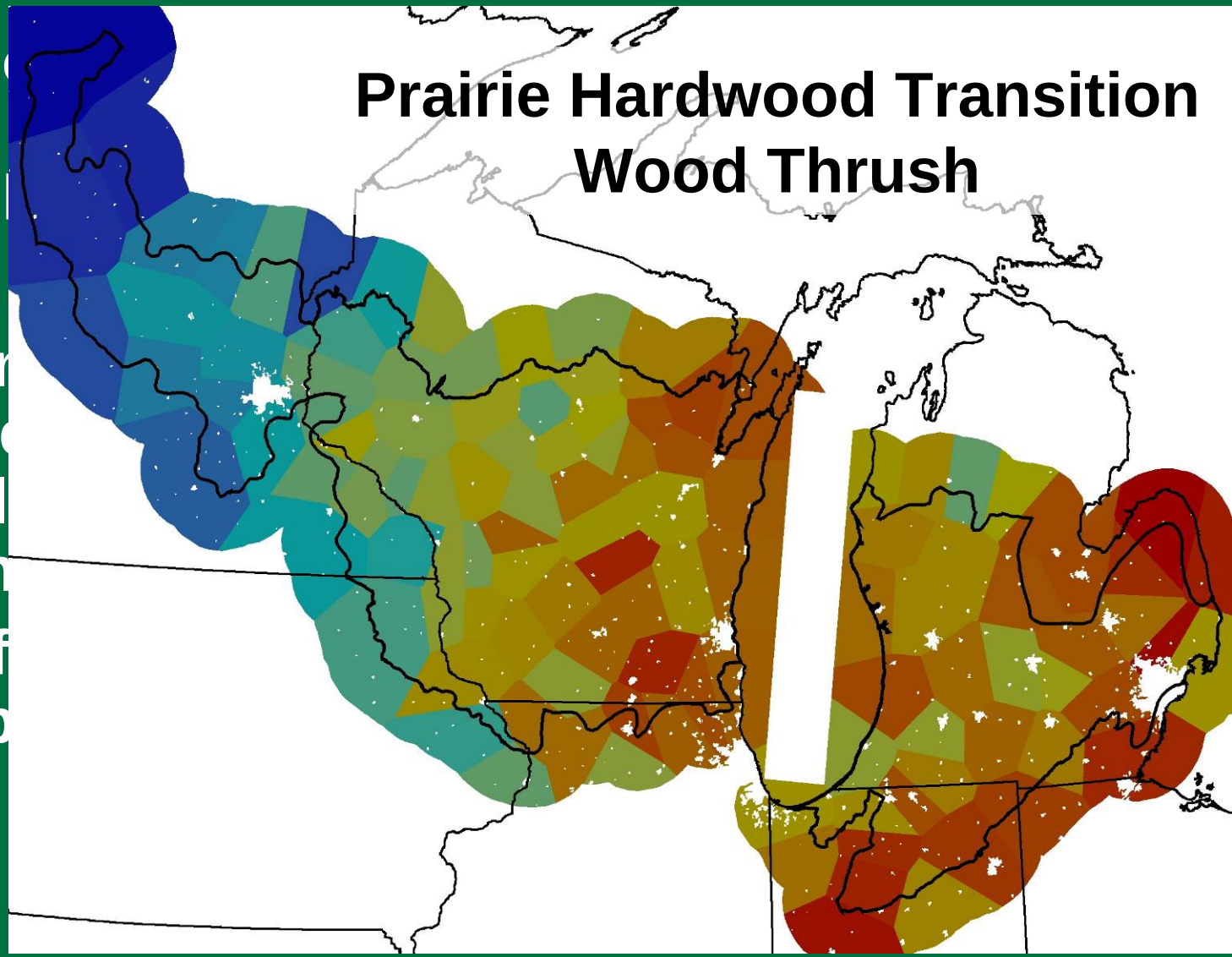

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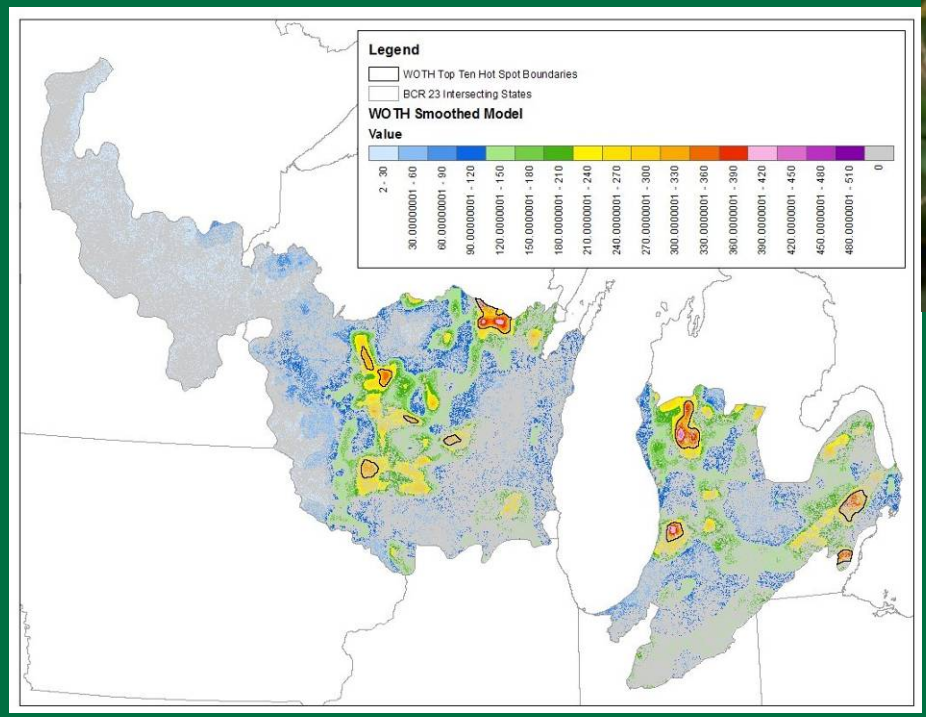
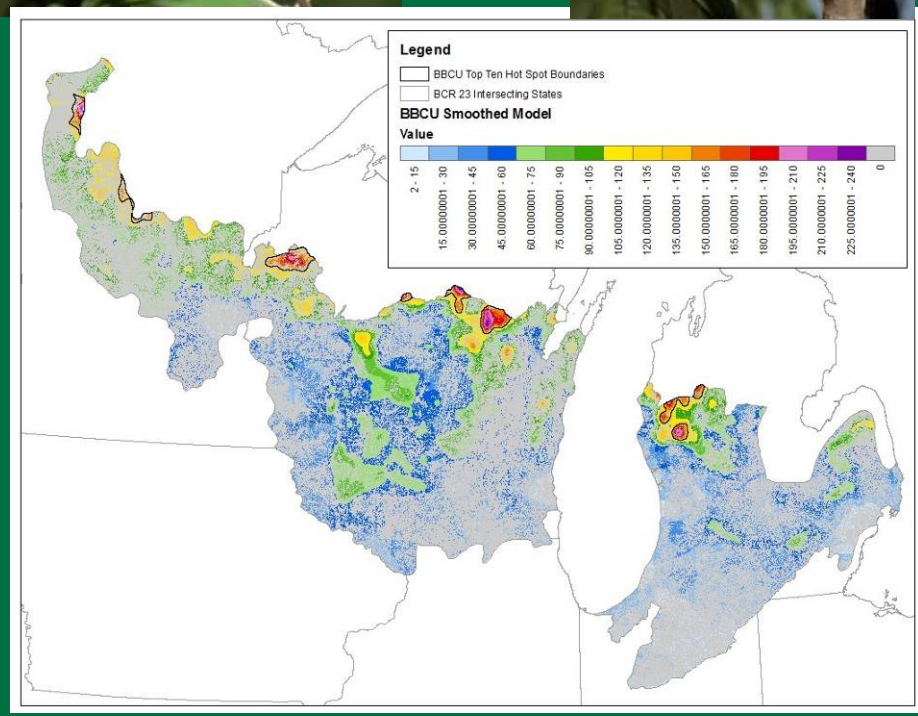
Regional Models of Rare Forest Bird Abundance

Wood Thrush





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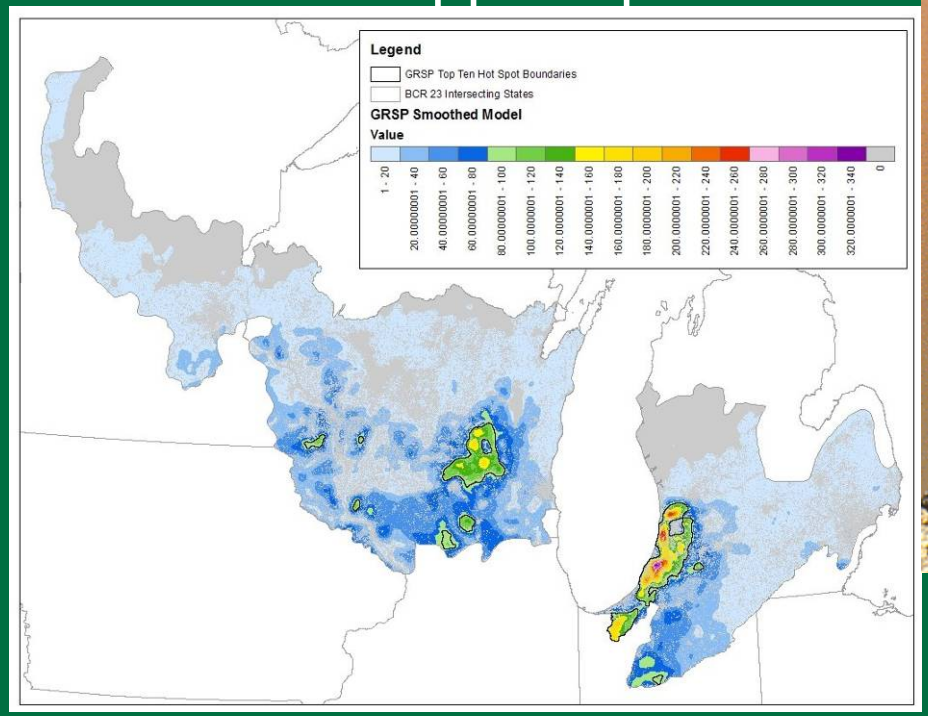
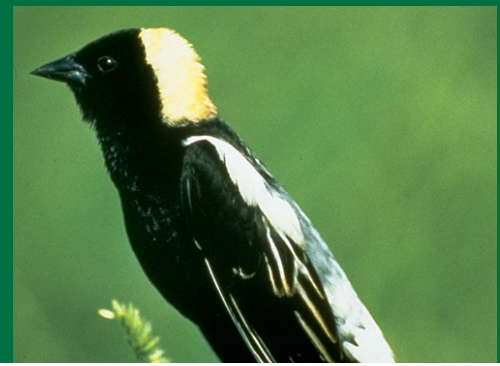
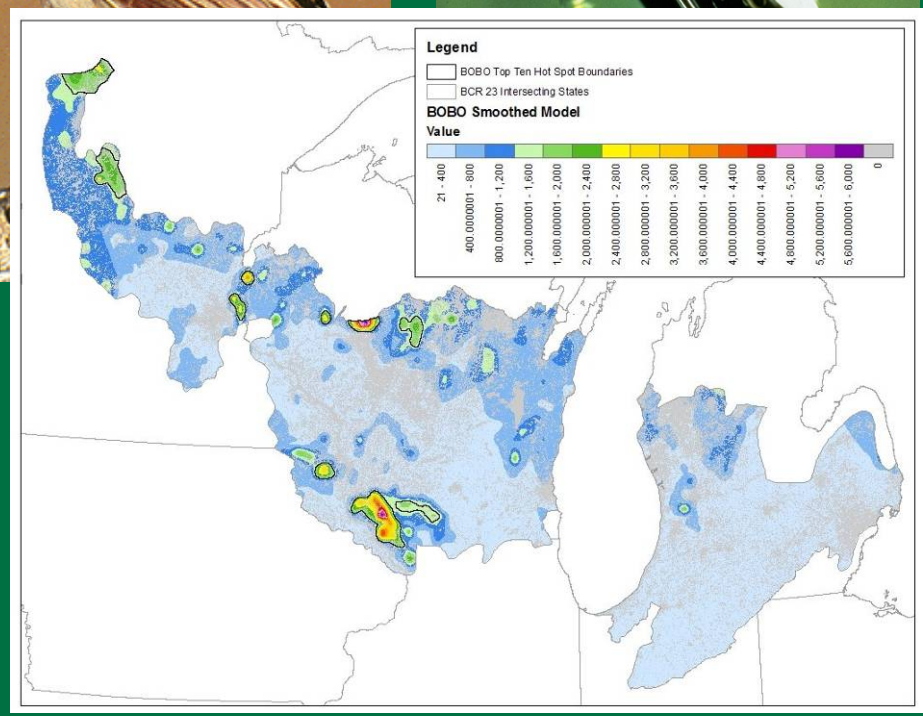
Black-billed Cuckoo

Regional Models of Rare Grassland Bird Abundance

Grasshopper Sparrow







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Federal Lands

Conservation insufficient on federal lands alone

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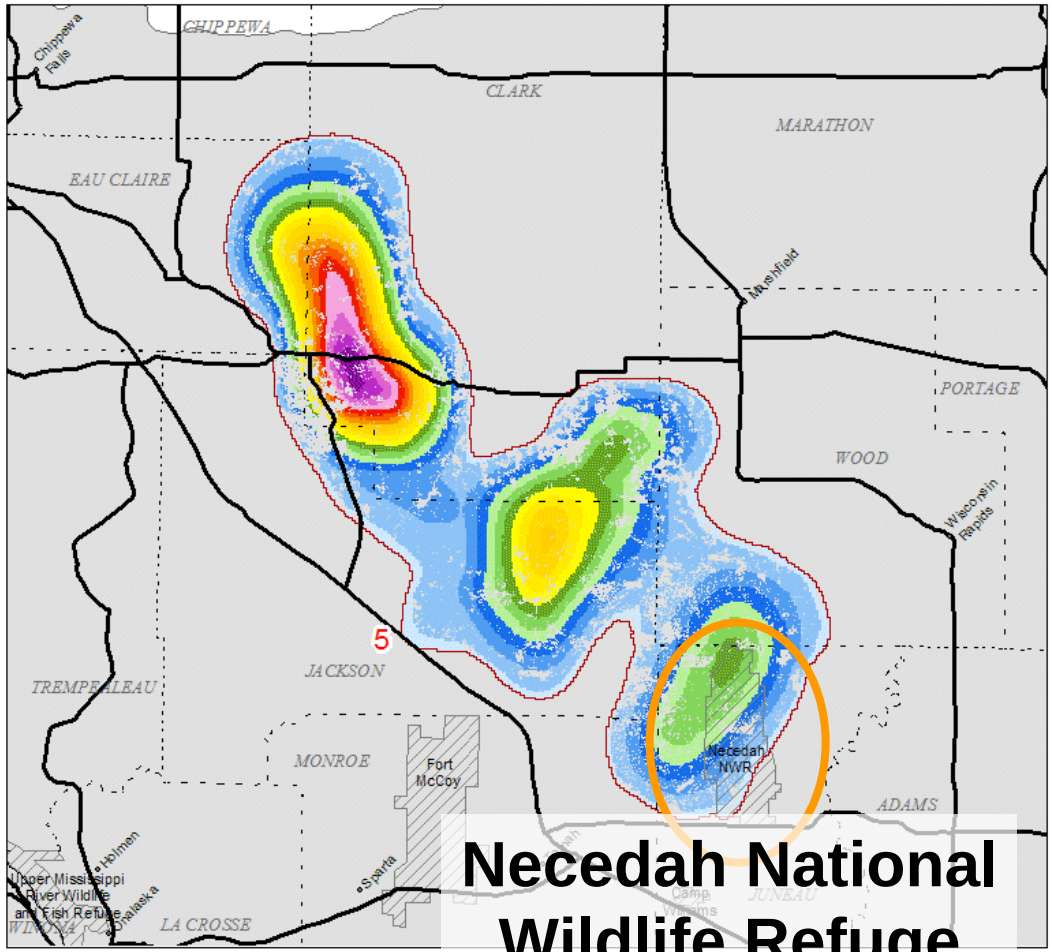
Smoothed Golden-Winged Warbler (GWWA) Model Overlayed with Federal Lands

Hotspot 5



Necedah National Wildlife Refuge

The Conservation Estate

Tribal Lands

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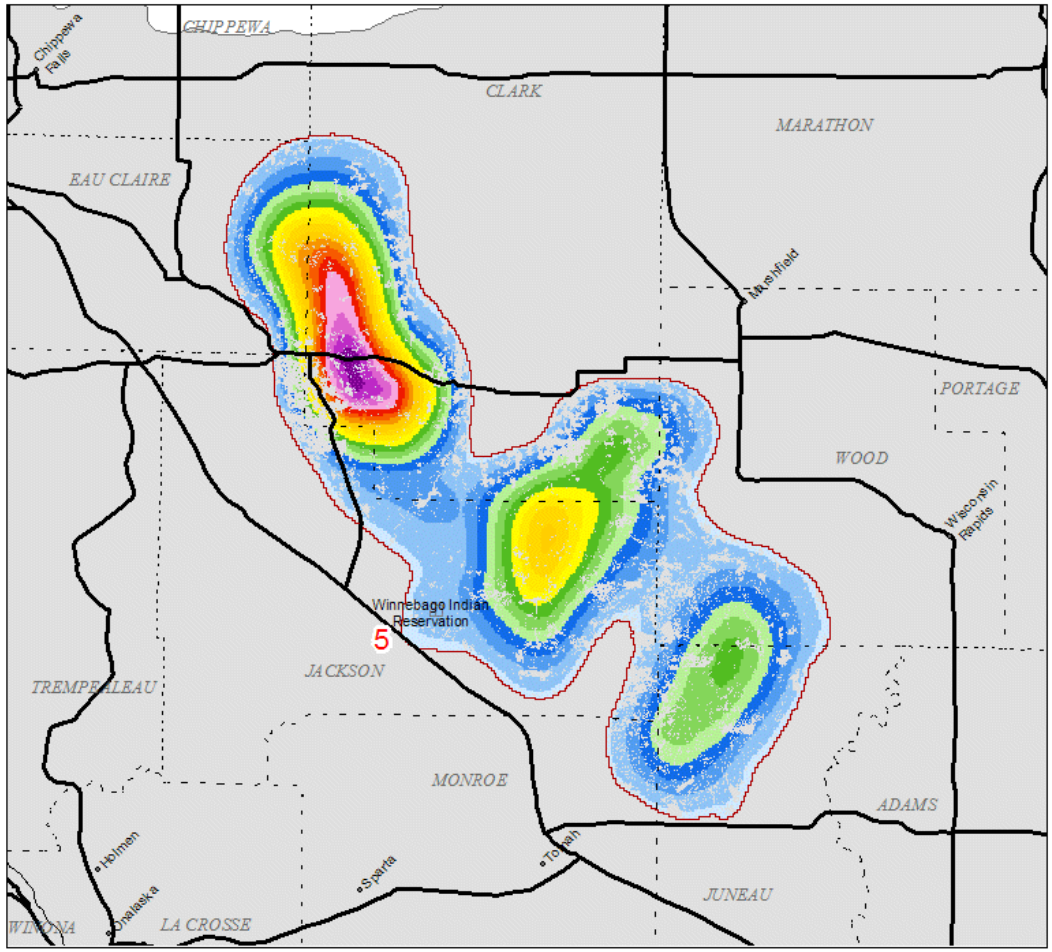
Smoothed Golden-Winged Warbler (GWWA) Model Overlayed with Tribal Lands

Hotspot 5



- Major Cities (pop2000 > 5,000)
- Major Roads
- Hotspot Boundaries
- States
- Counties
- Tribal Lands
- Bird Conservation Region (BCR) 23 Boundary

Smoothed GWWA Model (Top 5%)
Predicted Relative Abundance

0.85 - 1.0 | 1.0 - 1.5 | 1.5 - 2.0 | 2.0 - 2.5 | 2.5 - 3.0 | 3.0 - 3.5 | 3.5 - 4.0 | 4.0 - 4.5 | 4.5 - 5.0 | 5.0 - 5.5 | 5.5 - 6.0 | 6.0 - 6.5 | 6.5 - 7.0 | 7.0 - 7.5 | 7.5 - 8.0 | 8.0 - 8.5 | 8.5 - 9.0 | 9.0 - 9.5

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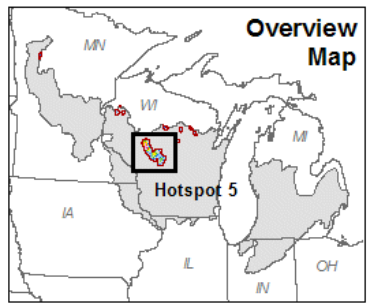

The Conservation Estate

State Lands

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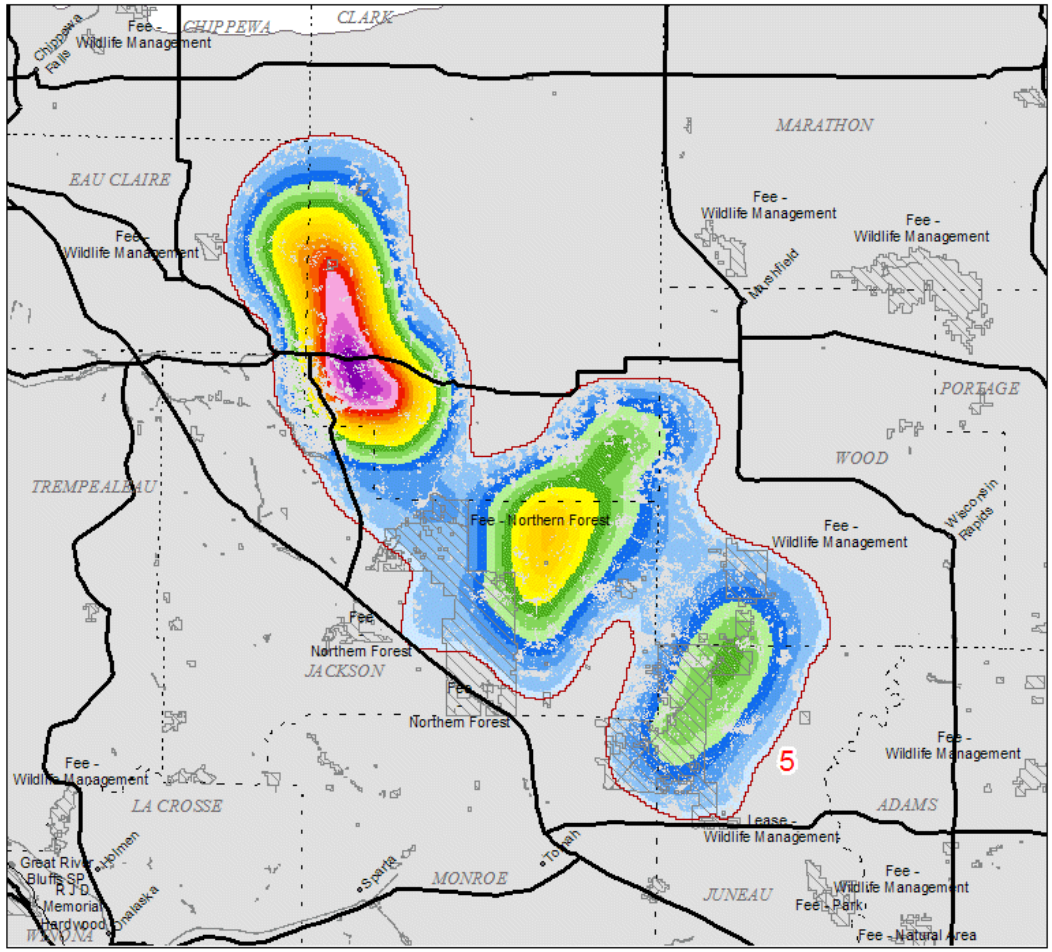
Smoothed Golden-Winged Warbler (GWWA) Model Overlayed with State Lands

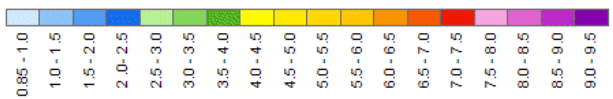
Hotspot 5



- Major Cities (pop2000 > 5,000)
- Major Roads
- Hotspot Boundaries
- State Managed Lands (polygons > 2,000 acres labeled)
- States
- Counties
- Bird Conservation Region (BCR) 23 Boundary

Smoothed GWWA Model (Top 5%)

Predicted Relative Abundance



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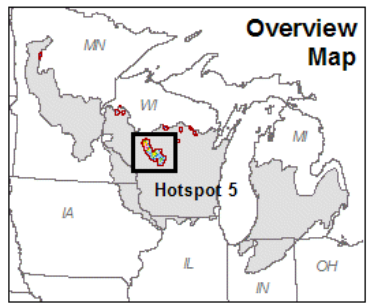

Private Lands Context in the Prairie Hardwood Transition

Area under state/federal/tribal land management ~9%

- CERW 66% of population under management
- SEWR 7%

- State lands provide 3-4 times the management opportunities

- 95% of rare grassland bird conservation to occur on private lands (vs 73% for rare forest birds)

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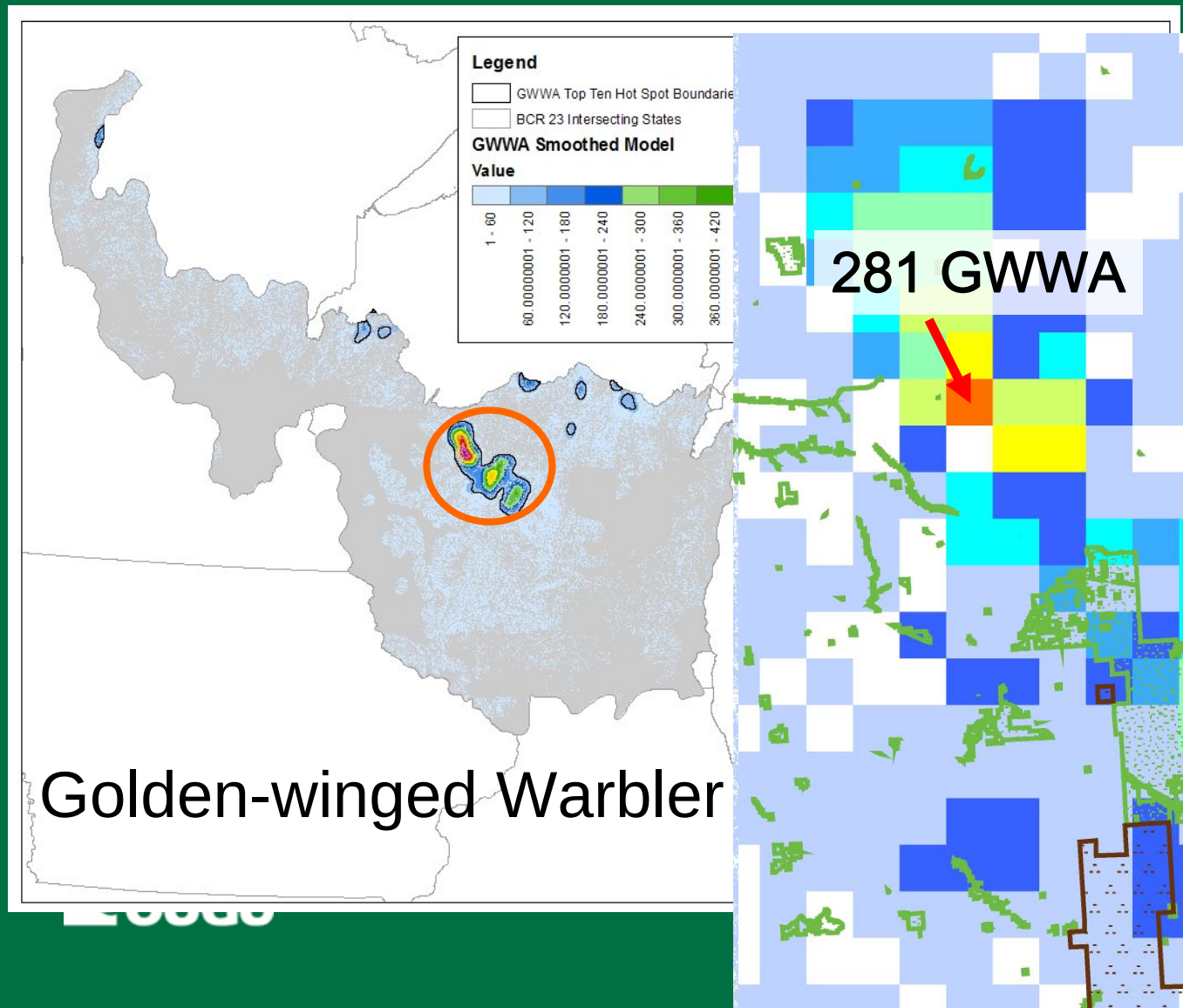
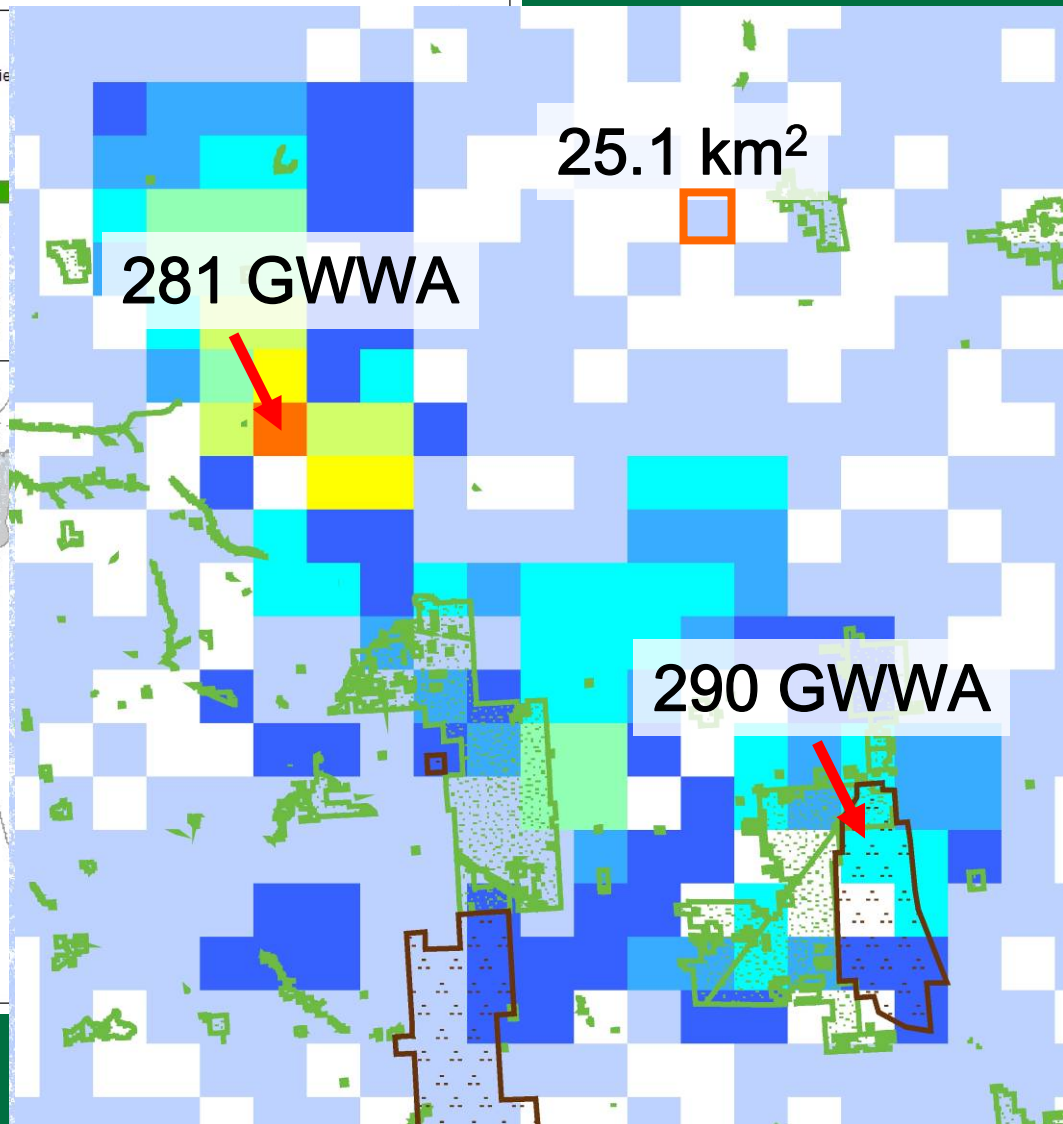
Stepping Down Regional Population Goals to Local Management Action





Conclusion: BBS data can be used to model avian habitat

- Focus habitat management on areas of predicted high or medium abundance
  - Consider location of public lands
- Build conservation partnerships
- Focus monitoring to detect change in vital rates (local) or population trend (regional)

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Questions?

- For more information

http://www.umesc.usgs.gov/terrestrial/migratory_birds/bird_conservation.html

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